Space Technology Research Grants

Electrolyte Engineering Toward Increasing Nonaqueous Lithium-Oxygen Battery Capacity

Completed Technology Project (2016 - 2018)

Project Introduction

With lithium-ion battery technology reaching its theoretical specific energy limit, electric vehicles, unmanned aerial vehicles, spacecraft and spacesuits alike require a breakthrough battery electrochemistry to unlock new range and capabilities. Among the beyond Li-ion battery chemistries studied to date, the nonaqueous lithium-oxygen battery has the highest theoretical specific energy. Critical scientific challenges prevent the realization of this high specific energy, however, including the insulating nature of the electrochemical discharge product, lithium peroxide. As lithium peroxide forms in the battery, it passivates the battery cathode, leading to low ultimate cell capacities. As a graduate student researcher at the University of California, Berkeley, I recently published work on the ability of an appropriately selected anion to increase solubility of the electrochemical intermediate to lithium peroxide formation, lithium superoxide (LiO_2), by lowering the free energy of the lithium cation (Li^+) in solution. I showed this increase in lithium superoxide solubility enhanced a different lithium peroxide growth mechanism, circumventing the passivation issue and increasing battery capacity. The effect of anion-induced solubility is limited, however, by the already low free energy of Li^+ in solution. As a next step, I hypothesize that the addition of appropriately selected non-Li alkali metal cations to the electrolyte in nonaqueous lithium-oxygen batteries will enhance LiO_2 solubility more so than the anions I previously studied by lowering the free energy of O_2^- in solution, resulting in a larger increase in battery capacity. To test this hypothesis, I plan to build laboratory-scale lithium-oxygen batteries containing electrolytes with and without non-Li alkali metal cations, and characterize battery capacity via galvanostatic cycling, lithium peroxide growth via scanning electron microscopy, and lithium superoxide solubility via nuclear magnetic resonance spectroscopy.

Anticipated Benefits

The work can benefit next generation electric vehicle, unmanned aerial vehicle, spacecraft and spacesuit development within NASA, other government, and industry.

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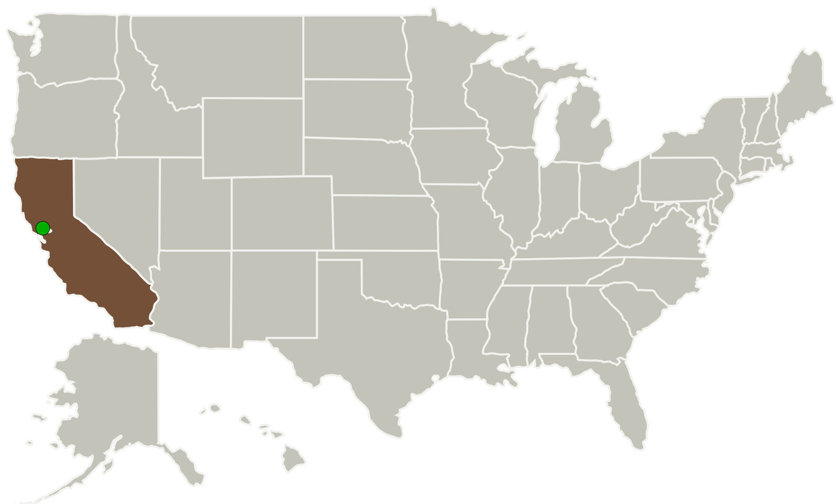
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
University of California-Berkeley(Berkeley)	Lead Organization	Academia	Berkeley, California
Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California

Primary U.S. Work Locations
California

Project Website:

https://www.nasa.gov/strg#.VQb6T0jJzyE

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

University of California-Berkeley (Berkeley)

Responsible Program:

Space Technology Research Grants

Project Management

Program Director:

Claudia M Meyer

Program Manager:

Hung D Nguyen

Principal Investigator:

Bryan Mccloskey

Co-Investigator:

Colin M Burke

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**

1	2	3	4	5	6	7	8	9
Applied Research			Development			Demo & Test		

Technology Areas

Primary:

- TX03 Aerospace Power and Energy Storage
  └ TX03.2 Energy Storage
    └ TX03.2.1 Electrochemical: Batteries

Target Destinations

The Sun, Outside the Solar System